FY03 Warning Guidance Proposal

Total Funds Requested

TIME Center:	**$180,000 from NTHMP Warning funds**
UH/ORE:	**$103,000 from Hawaii Mapping funds**

Period of Performance:

TIME Center:	**Seven months from receipt of funds**
UH/ORE:	**Twelve months from receipt of funds**

Background

The NTHMP has successfully developed and deployed a network of DART systems to provide real-time tsunami monitoring and measurement. The National Ocean Service also maintains a network of coastal tide gauges that are capable of reporting tsunami time series in real time. But inadequate tools exist to interpret these deep-ocean measurements in terms of potential impact on coastal communities. An integrated forecast guidance system is needed that combines this measurement technology with state-of-the-art tsunami numerical modeling technology. Model results that match the observations of a sparse network can be viewed as dynamic interpolators in both space and time, providing estimates of tsunami properties in the vast areas of the deep ocean and coastal regions where observations are lacking. This is not a new idea. Other forecast systems for different natural phenomena – most notably weather and climate forecasting – have used this approach, known formally as data assimilation and inversion, for decades.

In FY03 and earlier, the TIME Center has coordinated closely with PTWC, ATWC and the University of Hawaii Department of Ocean and Resources Engineering (UH/ORE) to develop a plan for implementation of a tsunami forecast guidance system. This proposal requests funds to begin the 2- to 3-year process of implementing such a system to provide real-time tsunami forecast guidance to NOAA's Tsunami Warning Centers and the Emergency Management agencies of the five Pacific States.

Work Statements and Costs

1. Manage Project

The work will be jointly managed by a senior scientist at the TIME Center and a senior scientist at the University of Hawaii Department of Ocean and Resources Engineering (UH/ORE)

TIME Labor:		
Senior Scientist (1 mo)	$17.2K	
UH/ORE Labor:		
Senior Scientist (1 mo)		$15.0K

2. Implement Prototype SIFT

In FY03 and earlier, the TIME Center has developed the prototype of a system known as SIFT (Short-term Inundation Forecasting for Tsunamis) that provides estimates of tsunami time series for offshore Hawaii, given a North Pacific earthquake in the Alaska-Aleutian, Cascadia , and Japan-Kurile Subduction Zones (Titov, et al, 2001; González, et al., 2002). This system exploits the Live Access Server (LAS) technology developed at PMEL to link individual remote databases and software tools in a way that provides the user with seamless access to a single, virtual database , analysis and visualization environment. To provide forecast guidance, SIFT must access PMEL computers on which reside two large databases – DART data continuously updated in real time, and pre-computed generation/propagation scenarios for "unit" North Pacific Subduction Zone earthquakes. This task would package the existing software into a system suitable for operational use and implement the package at PTWC and ATWC.

Deliverable: Prototype SIFT system implementation

TIME Labor:		
SIFT programmer (1 mo)	$ 8.8K	
LAS programmer (2 mo)	16.6K	
Subtotal	$25.4K	
UH/ORE Labor:		
Student programmer (1 mo)		$ 5.0K
Subtotal		$ 5.0K

3. Begin Implementation of SIFT Version 0.5

As described in the report on the 21 January 2003 Far-field Tsunami Forecasting Workshop (González, et al., 2003), Version 0,5 of the SIFT system will provide shoreline forecasts of time series of tsunami amplitude and currents, using three methodologies (WCATWC, UH/ORE and TIME), at a number of key "index sites" in each State and at South Pacific Islands, for Pacific Rim "unit" earthquake events. Maximum expected amplitude of later waves will also be estimated based on the statistical interpretation of tide gage data at these sites. To begin this implementation, an integrated system of deep ocean and coastal bathymetric grids must be constructed and South Pacific "unit sources" must be specified, to expand the forecast database of the prototype SIFT Version 0.1 to the entire Pacific. Each model must be tested on this grid system and production runs for all of the unit sources must be performed to generate the necessary forecast databases. DART and tide gage real-time data streams, and several different inversion schemes must be implemented and integrated into SIFT. Graphical products and user tools must be designed and included in the user interface. This is likely an 18- to 24-month project.

Deliverables: Pacific-wide forecast database
Integration of an index site for each State into SIFT user interface
Updated inundation maps for two Hawaii sites
Final report

Tasks and Budgets:

A. Develop Pacific-wide deep ocean, shelf and coastal embedded grid system.

TIME Labor:		
Bathy/topo grid developer (5 mo)	$ 41.6K	
Subtotal	$41.6K	
UH/ORE Labor:		
Student assistant (1.5 mo)		$ 7.5K
Subtotal		$ 7.5K

B. Develop S. Pacific sources; set up and test Pacific-wide models

TIME Labor:		
Tsunami modeler (3 mo)	$ 32.1K	
Senior scientist	17.2K	
Subtotal	$49.3K	
UH/ORE Labor:		
Student assistant (2.0 mo)		$ 10.0K
Subtotal		$ 10.0K

C. Production runs to develop generation, propagation and coastal time series databases

TIME Labor:		
Tsunami modeler (1 mo)	$ 10.6K	
Modeling assistant (4 mo)	35.2K	
Subtotal	$45.8K	
UH/ORE Labor:		
Student assistant (3.0 mo)		$ 15.0K
Subtotal		$ 15.0K

D. Develop SIFT Version 0.5 user interface: integrate and test Forecast tools, Later Waves tool, de-tided data stream, and forecast databases.

TIME Labor:		
Senior Scientist (2 mo)	$ 34.4K	
Junior scientist (2 mo)	20.7K	
SIFT Programmer (1.5 mo)	13.2K	
LAS Programmer (1 mo)	9.3K	
Subtotal	$77.6K	
UH/ORE Labor:		
Student assistant (2.0 mo)		$ 10.0K
Subtotal		$ 10.0K

4. Update Hawaii inundation maps for two communities

The grid and 2-dimensional tsunami model development performed in the course of the SIFT work will be exploited by the University of Hawaii to provide updated inundation maps for two coastal communities in Hawaii. The methodology, computational grids, and databases developed for the forecast system are also applicable to evacuation map production. We estimate that the value of the SIFT work that is directly applicable to the inundation mapping task is about $26K.

A small amount of additional support is required to collect and analyze historical runup records that are available for the major tsunami events that affected Hawaii over the last 100 years. Regression of the scattered runup records using the waterline time series will provide the inundation line for each of the tsunami events. The envelope of these inundation lines defines the 100-year tsunami inundation limits. Potential sites for evacuation map update include Kaiaka Bay, Hawaii Kai and Kaena-Haleiwa on Oahu; Kahalui Harbor, Maui; Haena-Kanalei, Kauai; and Kailua Bay and Hilo Bay on Hawaii. Cheung and Wei (2002) have shown that the present evacuation maps at Kaena-Haleiwa and Haena-Kanalei underestimate the 100-year inundation limits. Some of these are also index sites to be used for tsunami forecasting.

UH/ORE Labor:	
Student assistant (1.5 mo)	$ 7.5K
Senior Scientist (0.25 mo)	1.8K
Subtotal	$ 9.3K

5. Develop methodology for real-time inundation estimates in SIFT Version 1.0

As described in the report on the 21 January 2003 Far-field Tsunami Forecasting Workshop (González, et al., 2003) Version 1.0 of the SIFT system will provide inland

forecasts of flooding depth and currents. There are generally two approaches to providing these estimates in real-time, during an actual event -- real-time inundation model execution and non-linear interpolation schemes that operate on a pre-computed inundation database. It is critical that a fast, reliable methodology be developed well before implementation of Version 1.0. This task provides support for investigation of this issue.

The TIME Center will employ the finite difference model known as the Method of Splitting Tsunamis, or MOST (Titov and Synolakis, 1998). The UH will employ a finite volume model, which should produce more accurate runup predictions in comparison to conventional finite-difference models when the seabed slope is steep and when tsunami bores are developed. But while the inverse algorithm of Wei et al. (2003) can forecast tsunami time series at offshore locations, it is not applicable in the coastal region, where nonlinear effects are significant. A neural network may be able to resolve nonlinear data relations and interpolate coastal and waterline time series for tsunami height and runup forecasts at the index sites. To estimate the error in the seismic source approximations, a jackknife approach with a linear re-sampling scheme will be used. To transform this error through the nonlinear runup processes, a reliability model will be used. The forecast databases and algorithms will be tested using historical events with actual measurements of tide-gauge and runup records. Potential historical events that can be used for this validation include the 1946, 1964, and 1996 Alaska tsunamis as well as the 1952 Kamchatka tsunami. An interface program will be developed to link the package with the real-time data stream and automate the operating procedures at PTWC.

TIME Labor:		
Tsunami Modeler (1 mo)	$ 10.6K	
Senior scientist (1 mo)	17.2K	
Subtotal	$27.8K	
UH/ORE Labor:		
Senior Scientist (0.5 mo)		$ 3.5K
Student assistants (6 mo)		30.0K
Subtotal		$ 33.5K

6. Develop and publish final reports

Reports will be prepared and published for the work performed as part of this proposal: SIFT, Hawaii mapping, and development of inundation forecasting methodology.

TIME Labor:	
Tsunami Modeler (1 mo)	$ 10.6K
Two senior scientists (1 mo each)	34.4K
Two junior scientists (0.5 mo each)	8.6K

Subtotal	$53.6K	
UH/ORE Labor:		
Senior Scientist (1.25 mo)		$ 16.8K
Three student assistants (0.5 mo each)		15.0K
Subtotal		$ 31.8K
Total Labor Costs	$338.3K	$ 137.1K
Computer Costs	$10.0K	$ 7.5K
Travel Costs (including PTWC & WCATWC)	$15.0K	$ 15.5K
Total Cost	**$363.8K**	**$160.1K**
Matching Funds: NOAA/PMEL & UH/ORE	**-183.8K**	**-57.1K**
Net Cost	**$180.0K**	**$103.0K**

References

Cheung, K.F. and Wei, Y. (2002). Evaluation of Hawaii Tsunami Evacuation Maps. Report Prepared for Division of Civil Defense, Department of Defense, State of Hawaii.

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Wei, Y., Cheung, K.F., Curtis, G.D., and McCreery, C.S. (2003). Inverse algorithm for tsunami forecasts. *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 129(2), 60-69.